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Analysis Of The Quality Of Fresh Fruit Bunches (FFB) Of Oil Palm Received Using The Seven Tools And FMEA Methods (Case Study At Pt Sawit Inti Raya)

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Abstract

PT. Sawit Inti Raya is engaged in palm oil processing. This company was established because of the large potential market for palm oil processing and the large number of palm oil farmers in Riau. However, in recent times, PT. Sawit Inti Raya has faced a complex problem. The problem is the large number of damaged fresh fruit bunches provided by palm oil farmers and received by the company. The extent to which quality control in PT. Sawit Inti Raya's production is assessed in this study, the Seven Quality Control method is used. The data used in this study came from rejected products from February, March, and April 2024. At PT. Sawit Inti Raya, the highest level of defective products was caused by environmental conditions, overripe and damaged fruit bunches, and pests. The results of the study indicate that the most important improvements must be made. First, farmers must be trained in the correct FFB harvesting techniques, use monitoring tools, conduct regular inspections and use of pesticides, and monitor and adjust harvesting methods.

Keywords: Raw materials, Palm oil, Palm oil, Fresh fruit bunches, Fresh fruit bunch quality, Quality control

INTRODUCTION

The palm oil industry has become one of the most strategic sectors in Indonesia's economy, serving as a significant source of state revenue and employment for millions across the country (Palm and the G20, 2022). In 2023, the industry generated

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approximately IDR 88 trillion in tax and non-tax revenues and remained the largest contributor to Indonesia's non-oil and gas exports, accounting for about 3.5% of the national GDP annually (GAPKI, 2021). As the world's largest producer of palm oil, Indonesia bears a significant responsibility to ensure the quality of palm oil products exported to various countries (Palmoilmagazine, 2024). According to Sinambela (2020), fresh fruit bunches (FFB) play a crucial role as the primary raw material for crude palm oil (CPO) production, directly influencing both the quality and quantity of oil extracted.

To optimize the Oil Extraction Rate (OER), FFB used in palm oil processing must meet specific quality standards that include maturity, physical condition, moisture content, and cleanliness (Sinambela, 2020). The quality of FFB significantly affects the chemical composition of the resulting oil, including its free fatty acid (FFA) content, which, when excessive, can lower the quality of crude palm oil (Hasibuan, 2020). Previous research indicates that the water and oil content of palm fruits change during the ripening process. Fruits harvested prematurely contain higher moisture and lower oil content, while overripe fruits yield more oil but with higher FFA levels (Sinambela, 2020). Ensuring optimal fruit maturity for harvest remains a challenge, with variations in ripeness affecting both the oil yield and FFA levels in different parts of the bunch (Yee Being et al., 2020).

PT Sawit Inti Raya, a leading palm oil processing company, depends on high-quality FFB supplies to improve production efficiency and productivity. However, several challenges hinder quality control processes, one of which is maintaining a stable supply of FFB that meets quality standards. Delays between harvest and processing at the mill often result in low-quality FFB. Such delays can lead to reduced oil content and increased FFA levels, thus lowering production output and raising processing costs. Furthermore, weather changes, such as heavy rainfall, negatively affect the quality of FFB received at the mills. Rain may delay the transportation of harvested fruits, thereby increasing the moisture and FFA levels in FFB (Hasibuan, 2020).

To address these challenges, PT Sawit Inti Raya needs to implement stricter quality control measures to ensure that the FFB meets expected quality standards. This step is crucial for maintaining the company’s competitive edge, especially given the global market's demand for high-quality and sustainable palm oil products. The palm oil processing industry faces ongoing pressure to improve product quality standards due to growing competition. Consumers are increasingly concerned about the quality and sustainability of palm oil products, which are largely influenced by the quality of raw materials, particularly FFB. Thus, to remain competitive in the market, PT Sawit Inti Raya

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must conduct stringent quality control of incoming FFB and identify key components that affect quality.

This report aims to analyze the quality of FFB received by PT Sawit Inti Raya by identifying major issues related to the decline in FFB quality and providing recommendations for improvement. The analysis is expected to offer a clearer understanding of the importance of FFB quality management for the company and how appropriate measures can enhance efficiency, reduce production costs, and produce high-quality palm oil products that meet market demands.

LITERATURE REVIEW

Raw Materials

Raw materials are basic materials used in the production process or manufacturing of goods. These commodities are often traded on global commodity exchanges. In an economic context, companies acquire and sell raw materials in the market, because these materials play an important role as elements in the production process (Banton, 2023). Raw materials as raw materials have a crucial role in ensuring the smooth running of the production process. If the supply of raw materials is insufficient, this can cause disruption to production. In addition, the quality of raw materials greatly affects the quality of finished products (Astanti et al., 2020).

Palm Oil

According to the Department of Agriculture (2007), palm oil is an industrial and plantation crop that produces cooking oil, industrial oil, and fuel. Two palm species, *Elaeis guineensis* and *Elaeis oleifera*, are commercially cultivated for palm oil production. *Elaeis guineensis* originates from West Africa, between Angola and Gambia, while *Elaeis oleifera* is native to Central and South America. Palm oil gained popularity following the Industrial Revolution in the late 19th century due to the rising demand for vegetable oil for food and soap industries (Indonesian Plantation Agency, 2007). The oil palm tree can grow up to 24 meters, producing bunches of small, reddish-black fruits with oil-rich flesh and skin. The oil is widely used for cooking, soap production, and candles, while the residue serves as animal feed, particularly for poultry. Physiologically, the plant features compound dark green leaves, a trunk covered by frond scars for about 12 years, fibrous roots with aerial structures for aeration, and separate male and female flowers that mature at different times. Its fruits vary in color, ranging from black and purple to red, depending on the seed type. As the world's largest palm oil producer, Indonesia's palm oil industry

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directly and indirectly employs 16 million people, making it a vital strategic commodity for the country's economic development. Notably, palm oil has the highest economic value per hectare among all oil-yielding crops worldwide (Nasution et al., 2014).

Palm oil is a major global commodity dominating the vegetable oil market for the food industry and serving as a renewable biofuel source (Cattau et al., 2016). As the world's largest palm oil producer, Indonesia benefits economically from this industry (Mubarika Raisa et al., 2023). In 2009, data from the Central Statistics Agency indicated that almost all regions of Indonesia are suitable for palm oil plantations (Syahza & Asmit, 2019). A critical part of the palm oil plant is the Fresh Fruit Bunch (FFB), harvested and processed to produce palm oil, palm kernel oil, and other derivatives (Krisdiarto et al., 2017). Ensuring both the quantity and quality of FFB is essential for the palm oil industry. Proper harvesting methods and timing significantly affect FFB quality, with Free Fatty Acid (FFA) levels naturally increasing by 0.1% every 24 hours after harvest (Mangoensoekarjo & Semangun, 2008). The ideal FFA content should not exceed 2-3% when FFB enters the milling process. Physical damage during handling, such as bruising, accelerates lipase enzyme activity, leading to a rapid increase in FFA levels (Hardani et al., 2020). Therefore, meticulous planning of harvesting and transportation is crucial to achieve optimal oil productivity, acceptable quality, and cost efficiency. Maturity level is also a key determinant of FFB quality, as fully ripe FFB contains the highest oil content and the lowest FFA levels (Razali et al., 2012). Proper maturity fractions during harvest directly impact palm oil yields and FFA levels, with higher fractions improving oil yield but potentially increasing FFA content if mishandled.

Quality Control

Quality control is a crucial component in every industry to ensure that products or services meet specific standards. According to Besterfield et al. (2018), quality control refers to the processes and actions used to meet requirements and enhance customer satisfaction by fulfilling their expectations. In the palm oil plantation industry, quality control plays a vital role in maintaining high standards for palm oil products. It ensures that the established standards for harvesting, processing, and storing palm fruits are met, ultimately producing high-quality palm oil. This not only satisfies customers but also enhances the reputation of plantations and the industry as a whole. Quality control involves monitoring various aspects, such as fruit maturity, processing time, and storage conditions. By implementing quality checks at each production stage, plantations can ensure that the final product meets expected specifications through regular inspections,

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testing, and documentation. In conclusion, quality control is essential in the palm oil plantation industry as it helps improve product quality, boosts customer satisfaction, and provides a competitive market advantage. Further research is encouraged to explore how quality control impacts palm oil product quality in this sector.

Seven Tools

The seven tools for quality control are basic statistical instruments designed to effectively solve problems. These tools were introduced and developed in Japan by quality experts such as Deming and Juran. According to Kaoru Ishikawa, these tools can address up to 95% of existing issues. They played a significant role in the resurgence of Japan's industries after World War II. The QC tools include the Pareto Diagram, Cause & Effect Diagram, Histogram, Control Charts, Scatter Diagrams, Graphs, and Check Sheets. These tools are essential in manufacturing industries for monitoring operations and promoting continuous process improvement. By utilizing these tools, the root causes of problems can be identified and resolved, ultimately improving manufacturing processes. Direct observations on production lines and statistical tools are also used to investigate types of defects on the production line.

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a systematic approach for identifying potential failures in designs, processes, or systems. It involves analyzing possible failure modes, their impact on the system, and their criticality levels. FMEA is used to assess the risks associated with different failure modes and prioritize actions to reduce or eliminate these failures (D.H. Stamatis, 2003). As a crucial tool for proactively identifying and mitigating potential failures, FMEA enables organizations to prioritize actions based on identified risks and implement changes to enhance reliability, safety, and quality. Due to its effectiveness in reducing failures and improving overall performance, FMEA has been widely adopted across various industries, including aerospace, automotive, healthcare, and manufacturing (Sharma and Srivastava, 2018).

RESEARCH FRAMEWORK

Based on the description and explanation of theoretical investigations and hypotheses, a research model can be created which is used in this research. This research model is shown in the following figure:

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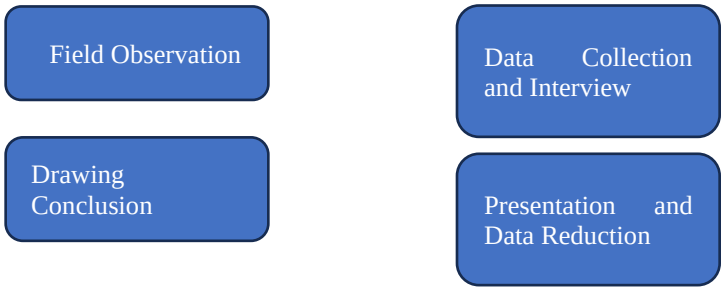


Figure 1. Research Framework

RESEARCH METHODS

This research was conducted at PT Sawit Inti Raya, located in Bongkal Malang Village, Kelayang Sub-district, Indragiri Hulu Regency, Riau Province. The company operates in the palm oil processing industry, with the primary focus of this study being the production team, specifically the quality control division. The research aims to identify factors contributing to the low-quality fresh fruit bunches (FFB) supplied to the company and propose solutions to improve their quality.

Data collection in this qualitative study involved three primary methods: observation, interviews, and documentation. Direct observation allowed researchers to examine the quality control processes firsthand, including FFB sorting and measurement activities. Interviews were conducted with key personnel, such as the factory manager, sorting assistant, and process assistant, providing valuable insights into operational challenges and practices. Documentation further supported the research by capturing photographic evidence of quality control processes and interview records. The integration of these methods enabled a comprehensive understanding of the company's FFB quality issues and guided recommendations for improvement.

RESULTS

Seven Tools Method

The Seven Tools method was applied to process data on defective fresh fruit bunch (FFB) reception at PT Sawit Inti Raya in 2024. One of the key tools used was the Check Sheet, which systematically collects and organizes data to analyze problem patterns. In this study, the Check Sheet was utilized to identify recurring patterns in the reception of FFB that did not meet quality standards or showed defects, providing valuable insights for addressing quality control issues.

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Table 1. Check Sheet

Month	Receipt (Tandan)	Disability Receipt (Tandan)
February	198579	3219
March	274889	4367
April	384567	2219

The Check Sheet analysis revealed that February recorded the highest number of defective fresh fruit bunch (FFB) receptions, with 4,367 defective bunches, while March had the lowest with 2,219 defective receptions. The Pareto Diagram was then used to visualize and prioritize these defects based on their frequency, arranged from the most to the least significant issues. The data shows five types of defects: environmental conditions (43%), overripe and damaged bunches (27.5%), pest issues (15.4%), high moisture content (10.5%), and harvesting techniques (3.6%). According to the Pareto principle, the study focuses on the three most dominant defect types—environmental conditions, overripe and damaged bunches, and pest issues—since they account for the majority of defects. Environmental conditions were identified as the most critical factor, while harvesting techniques contributed the least.

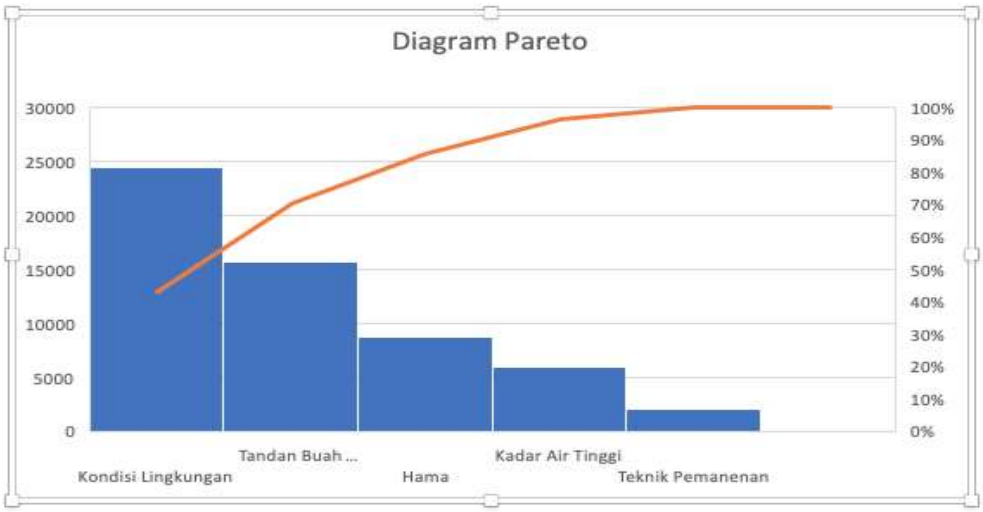


Figure 2. Pareto Diagram

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A histogram is used to display the distribution or frequency of different values within a dataset. Based on the previous Pareto Diagram analysis, the data focuses on the three most significant defect types that occurred from February to April 2024. The table highlights defects caused by environmental conditions (24,506 units, 43%), overripe and damaged bunches (15,670 units, 27.5%), and pest issues (8,796 units, 15.4%). As shown in the histogram, defects due to environmental conditions have the highest frequency, accounting for 24,506 defective bunches or 43% of the total defects. This emphasizes the critical impact of environmental conditions on fresh fruit bunch quality.

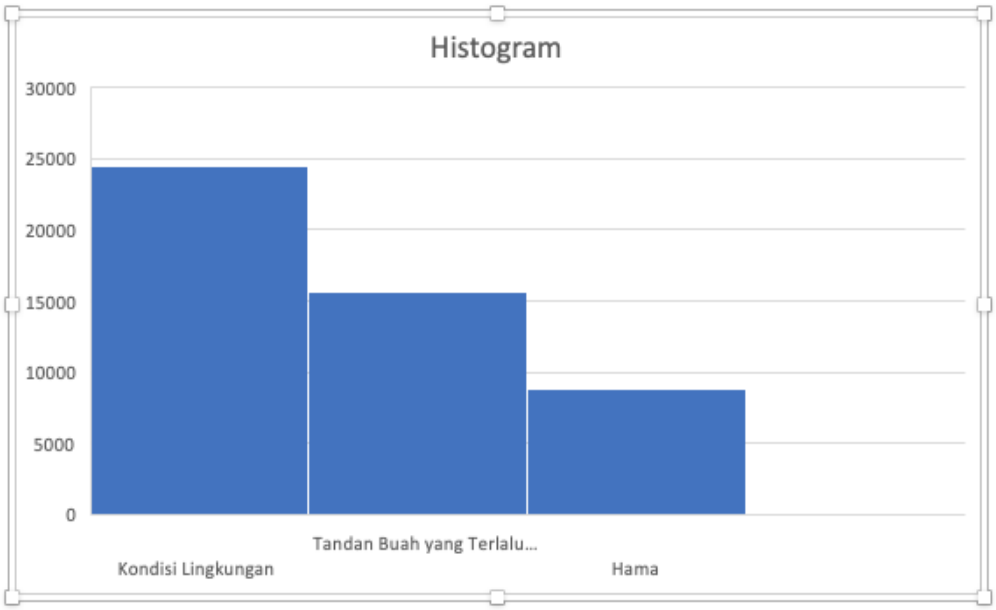


Figure 3. Histogram

The Fishbone Diagram analysis is a structured approach that enables detailed examination to identify the root causes of problems, discrepancies, and gaps (Gaspers V, 2002). This analysis focused on defects caused by environmental conditions, overripe or damaged fresh fruit bunches (FFB), and pest issues, considering factors related to machinery, raw materials, work methods, and human factors. For defects due to environmental conditions, extreme weather and humidity during planting, growth, and harvesting phases were key raw material factors. Poor maintenance of transport machinery and inefficient shipping and storage methods further contributed, alongside poor delivery planning and a lack of knowledge about environmental impacts. For overripe or damaged FFB, poor seed quality, suboptimal harvesting equipment, and errors in

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harvest scheduling were key contributors, exacerbated by human decision-making mistakes. In terms of pest-related defects, weak plant resistance, ineffective machinery, irregular pesticide application, and poor agricultural practices, as well as inadequate plant care and lack of knowledge, were identified as major factors.

Failure Mode Effect Analysis Method (FMEA)

Failure Mode and Effect Analysis (FMEA) is a method used to identify, recognize, and reduce potential failures before they reach consumers (Nannikar, 2012). The table below displays the Severity, Occurrence, and Detectability values as well as the final RPN values given directly by the head of quality control of PT. Sawit Inti Raya, which in each table consists of the 3 largest types of defects consisting of environmental conditions, overripe or damaged fruit bunches, and ham. The results of this description are an elaboration of the cause and effect diagram that has been discussed above. The following is the taking of the RPN values that occurred at PT. Sawit Inti Raya.

Table 2. Failure Mode Effect Analysis (FMEA) calculation

Mode Of Failure (Defect)	Potential Failure	SEV	Cause Of Failure	OCC	Current Process Control	DET	RPN	Ranking
Environmental conditions	Extreme weather affects FFB	6	Heavy rain or drought	7	Weather monitoring and adjustment of harvesting methods	5	210	2
Overripe or damaged TB	Late harvesting	8	Harvest schedule errors	8	Training and use of harvest time monitoring tools	6	384	1
Pests	Damage by pest attacks	5	Ineffective pest control	5	Regular inspection and periodic use of pesticides	4	100	3

DISCUSSION

The use of weather-tolerant plant materials can help mitigate the negative impact of extreme rainfall and drought on the quality of fresh fruit bunches (FFB). Research shows that adapting plant materials to local climatic conditions is an effective strategy for coping with climate change (Murphy et al., 2021). Additionally, implementing agronomic

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adjustment strategies, such as optimizing planting density and applying appropriate fertilizers, can further minimize the impact of extreme weather on FFB growth and quality (Abubakar et al., 2023). Proper soil moisture management and water conservation techniques, including the use of drip irrigation and organic mulching, can help maintain FFB quality even under unpredictable weather conditions (Khan et al., 2024).

The adoption of technological maturity detection systems can optimize harvest timing. Advanced technologies such as deep learning systems or smartphone-based maturity detectors can classify FFB maturity in real-time, enabling more precise decision-making (Suharjito et al., 2023). Furthermore, analytics-driven harvest schedule optimization, using models that combine simulations and prescriptive recommendations, can help reduce scheduling errors by analyzing historical and current data (Escallón-Barrios et al., 2022). Visual and image processing techniques for maturity assessment can also enhance accuracy in determining the optimal harvesting stage, ensuring FFB is collected at its prime maturity (Saeed et al., 2012).

Integrated Pest Management (IPM) is a comprehensive approach that includes pest identification, population monitoring, threshold determination, and exploration of appropriate control measures. This approach reduces negative environmental impacts by combining biological controls, natural predator use, and limited pesticide application (Teng, 2024). Biological control agents, such as predators, parasitoids, and antagonistic microorganisms, can effectively manage pests without synthetic chemicals. For example, ants and other predator insects help control leaf caterpillars in palm plantations.

The creation of palm tree varieties with enhanced resistance to pest attacks offers another solution to reduce crop damage. This process involves plant breeding to strengthen the natural pest resistance of palm trees, contributing to better crop protection and improved production efficiency (Egonyu et al., 2022).

CONCLUSION

After processing and analyzing the data, several conclusions aligned with the research objectives can be drawn. The findings indicate that three primary issues hold the highest priority: environmental conditions, overripe or damaged fresh fruit bunches (FFB), and pest-related defects. The Risk Priority Numbers (RPN) for each defect are as follows: extreme weather conditions contributed to environmental defects with an RPN of 210; delayed harvesting caused overripe or damaged FFB with an RPN of 384; and pest attacks, delayed in management, resulted in defects with an RPN of 100. The analysis further demonstrates that no single component exclusively caused these defects. Instead,

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quality degradation was partially attributed to raw material conditions and human resource factors. Therefore, evaluations should address the raw material conditions, surrounding environments, and farmer capabilities, particularly concerning proper operational procedures in line with company regulations. The study found that factors such as improper handling time between harvesting and processing and unfavorable weather conditions contributed to the decline in FFB quality. This decline directly affects production efficiency and the final product quality of palm oil. As a result, stricter and more organized quality control is essential to ensure that FFB meets expected standards. The analysis provides several recommendations for improving the quality control system to enhance the company's productivity and competitiveness in the increasingly challenging global market.

RECOMMENDATION

To address the decline in the quality of Fresh Fruit Bunches (FFB) at PT Sawit Inti Raya, several strategic actions focusing on raw materials and human resources are recommended. Future research can explore more efficient methods for training employees in FFB harvesting and processing, investigate innovative ideas for post-harvest and harvesting management, and analyze their impact on FFB quality. Additionally, studies could examine the implementation of strict supervision systems for daily employee activities and assess the potential of contemporary technologies, such as real-time sensors for raw material monitoring, to improve production efficiency and product quality. For the company, routine employee training should be conducted to improve operational efficiency and FFB quality, emphasizing proper harvesting methods and post-harvest management. Implementing a strict supervision system and periodic performance evaluations would provide valuable feedback and identify areas for improvement. Performance-based incentive programs could motivate employees to achieve quality standards. Selecting high-yield palm varieties with superior FFB quality, optimizing transportation from plantation to mill, and using proper storage methods, such as cooling systems, are also essential to prevent damage. Regular quality analyses of oil content, Free Fatty Acid (FFA) levels, and contaminants should be performed. By adopting these measures, PT Sawit Inti Raya can enhance its raw material quality and improve competitiveness in the global palm oil market.

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MANAGERIAL IMPLICATIONS

The findings of this study highlight the critical need for PT Sawit Inti Raya to adopt more comprehensive quality control measures and strategic operational improvements. Management should prioritize the use of weather-tolerant plant materials to mitigate the impact of extreme weather conditions and invest in advanced technologies, such as real-time maturity detection systems, to optimize harvesting schedules. Employee training programs focused on proper harvesting and post-harvest practices are essential to reduce defects caused by overripe or damaged FFB. Additionally, implementing Integrated Pest Management (IPM) strategies can help reduce the impact of pest-related defects. By integrating these measures, the company can enhance production efficiency, maintain high product quality, and remain competitive in the global palm oil market.

RESEARCH LIMITATIONS

This study has certain limitations that should be addressed in future research. The analysis was confined to three key defect types—environmental conditions, overripe or damaged FFB, and pest-related issues—without exploring other potential factors that may impact FFB quality. Furthermore, the study relied heavily on qualitative data from interviews and observations, which may be subject to bias or limitations in scope. Additional quantitative data, such as detailed metrics on harvesting timelines and pest control effectiveness, could provide a more comprehensive view. Future studies are encouraged to explore the role of technological advancements, such as predictive analytics and automated quality monitoring systems, in improving production efficiency and product quality in the palm oil industry.

REFERENCE

Abubakar, A., Gambo, J., & Ishak, M. Y. (2023). *Navigating climate challenges: Unraveling the effects of climate change on oil palm cultivation and adaptation strategies* (pp. 95–116). https://doi.org/10.1016/bs.af2s.2023.07.002

Anggito, A., & Setiawan, S.Pd., J. (2018). Metodologi penelitian kualitatif. CV Jejak (JejakPublisher).

Arikunto, S. (2006). Prosedur Penelitian : Suatu Pendekatan Praktik. Edisi Revisi VI. Jakarta : PT Rineka Cipta.

Astanti, R. D., Mbolla, S. E., & Ai, T. J. (2020). Raw material supplier selection in a glove manufacturing: Application of AHP and fuzzy AHP. Decision Science Letters, 9(3), 291–312. https://doi.org/10.5267/j.dsl.2020.5.005

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Banton, C. (2023). Raw Materials: Definition, Accounting, and Direct vs. Indirect. Investopedia.Com.

Bungin, B. (2003). Metode Penelitian Kualitatif. Jakarta : Raja Grafindo Persada. p. 147.

Cattau, M. E., Marlier, M. E., & DeFries, R. (2016). Effectiveness of Roundtable on Sustainable Palm Oil (RSPO) for reducing fires on oil palm concessions in Indonesia from 2012 to 2015. *Environmental Research Letters, 11*(10).https://doi.org/10.1088/1748-9326/11/10/105007

D.H. Stamatis (2003) Failure Mode and Effect Analysis. AmericanSociety for Quality, Quality Press, Milwaukee

Egonyu, J. P., Baguma, J., Martínez, L. C., Priwiratama, H., Subramanian, S., Tanga, C. M., Anankware, J. P., Roos, N., & Niassy, S. (2022). Global Advances on Insect Pest Management Research in Oil Palm. *Sustainability*, *14*(23), 16288. https://doi.org/10.3390/su142316288

Escallón-Barrios, M., Castillo-Gomez, D., Leal, J., Montenegro, C., & Medaglia, A. L. (2022). Improving harvesting operations in an oil palm plantation. *Annals of Operations Research*, *314*(2), 411–449. https://doi.org/10.1007/s10479-020-03686-6

Hardani, Helmina, Jumari, & Evi. (2020). Metode Penelitian Kualitatif dan Kuantitatif. Pustaka Ilmu Group.

Khan, N., Kamaruddin, M. A., Sheikh, U. U., Bakht, M. P., Mohd, M. N. H., & Ab Rahman, A. A.-H. (2024). Analysis of weather impacts on oil palm productivity. 060003. https://doi.org/10.1063/5.0232251

Krisdiarto, A. W., Sutiarso, L., & Widodo, K. H. (2017). Optimasi Kualitas Tandan Buah Segar Kelapa Sawit dalam Proses Panen-Angkut Menggunakan Model Dinamis. Agritech, 37(1), 102.https://doi.org/10.22146/agritech.17015

Lubis. (1995). Prosiding forum komunikasi kelapa sawit IV. Pusat Penelitian Kelapa Sawit.

Mangoensoekarjo, S., & Semangun, H. (2008). Manajemen Agrobisnis Kelapa Sawit. Gadjah Mada University Press.

Mubarika Raisa, D., Nurani Sirajuddin, S., Ahmari Syamsu, J., Darsono, W., & Syarifuddin, N. A. (2023). Strengthening local institutions for cattle-palm oil integration to increase beef self-sufficiency and palm oil sustainability (Case Study: SISKA-KUINTIP in Tanah Bumbu, South Kalimantan Province). Indonesian Agricultural Research Journal, 1(2), 106–120. https://doi.org/10.20956/ia.v1i2.32233

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Murphy, D. J., Goggin, K., & Paterson, R. R. M. (2021). Oil palm in the 2020s and beyond: challenges and solutions. *CABI Agriculture and Bioscience*, *2*(1), 39. https://doi.org/10.1186/s43170-021-00058-3

Nasution, S. H., Hanum, C., & Ginting, J. (2014). Pertumbuhan Bibit Kelapa Sawit (Elaeis Guineensis Jacq.) Pada Berbagai Perbandingan Media Tanam Solid Decanter Dan Tandan Kosong Kelapa Sawit Pada Sistem Single Stage. Jurnal Agroekoteknologi Universitas Sumatera Utara, 2(2). https://doi.org/10.32734/jaet.v2i2.7076

Nazir, M. (2011). Metode Penelitian. Bogor: Penerbit Ghalia Indonesia.

Pahan, I. (2006). Panduan Lengkap Kelapa Sawit, Manajemen Agribisnis dari Hulu Hingga Hilir. Penebar Swadaya.

Poerwandari, E.K. (1998). Pendekatan Kualitatif dalam Penelitian Psikologi. Jakarta: Fakultas Psikologi Universitas indonesia.

Priwiratama, H., Susanto, A., & Prasetyo, A. (2018, December). *BIOLOGICAL CONTROL OF OIL PALM INSECT PESTS IN INDONESIA*.

Saeed, O. M. Ben, Sankaran, S., Shariff, A. R. M., Shafri, H. Z. M., Ehsani, R., Alfatni, M. S., & Hazir, M. H. M. (2012). Classification of oil palm fresh fruit bunches based on their maturity using portable four-band sensor system. *Computers and Electronics in Agriculture*, *82*, 55–60. https://doi.org/10.1016/j.compag.2011.12.010

Sekaran, U. and, & Bougie, R. (2016). Research Methods for Business A Skill-Building Approach Seventh Edition. John Wiley & Sons.

Sharma KD, Srivastava S. Failure Mode and Effect Analysis (FMEA) Implementation: A Literature Review. J Adv Res Aero SpaceSci 2018; 5(1&2): 1-17.

Sprinthall, R. C. (2011). Basic statistical analysis 9th Edition. London: Pearson. 672 pages.

Sugiyono (2012), Memahami Penelitian Kualitatif. Bandung : Alfabeta

Sugiyono. (2014). Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta.

Sugiyono. (2019). Metode Penelitian Kuantitatif Kualitatif dan R & D. Alfabeta.

Suprayogo, I. (2001). Metodologi Penelitian Sosial Agama. Bandung : PT. Remaja Rosdakarya. p. 71.

Syahza, A., & Asmit, B. (2019). Development of palm oil sector and future challenge in Riau Province, Indonesia. Journal of Science and Technology Policy Management, 11(2), 149–170. https://doi.org/10.1108/JSTPM-07-2018-0073

GAPKI. (2021, September 22). Palm oil has irreplaceable role in Indonesian economy.

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Gabungan Pengusaha Kelapa Sawit Indonesia (GAPKI). https://gapki.id/en/news/2021/09/22/palm-oil-has-irreplaceable-role-in-indonesian-economy/

Hasibuan, H. A. (2020). Penentuan Rendemen, Mutu dan Komposisi Kimia Minyak Sawit dan Minyak Inti Sawit Tandan Buah Segar Bervariasi Kematangan sebagai Dasar untuk Penetapan Standar Kematangan Panen. Jurnal Penelitian Kelapa Sawit, 28(3), 123–132. https://doi.org/10.22302/iopri.jur.jpks.v28i3.106

Palm and the G20. (2022, November 8). Indonesia Palm Oil Facts. Indonesia Palm Oil Facts.https://www.indonesiapalmoilfacts.com/g20/

Palmoilmagazine. (2024, September 16). Palm oil contributes around IDR 88 trillion to Indonesia's revenue by 2023. Palmoilmagazine.Com. https://www.palmoilmagazine.com/hot-news/2024/09/17/palm-oil-contributes-around-idr-88-trillion-to-indonesias-revenue-by-2023/

Sinambela, R. (2020). A Ripeness Study of Oil Palm Fresh Fruit at the Bunch Different Positions. Jurnal Keteknikan Pertanian, 8(1), 9–14. https://doi.org/10.19028/jtep.08.1.9-14

Teng, Y. Y. (2024, May). *Integrated Pest Management (IPM) for Sustainable Palm Oil Production*. Www.Musimmas.Com.

Yee Being, C., Maringgal, B., Hashim, N., & Hafizz Wondi, M. (2020). A review of non-destructive techniques applied for measuring quality of oil palm fresh fruit bunches. Journal of Agricultural and Food Engineering, 1(1), 1–6.https://doi.org/10.37865/jafe.2020.0002

Yin. R. K. (2014). Case study research design and methods (5th ed.). Thousand Oaks, CA: Sage. 282 pages

Wirartha, I. M. (2006). Metodologi Penelitian Sosial Ekonomi. Yogyakarta: CV. Andi Offset., p. 155.

Zikmund, W., & Babin, B. (2006). Exploring Marketing Research William.

Zikmund, W. G., & Babin, B. J. (2010). Exploring Marketing Research (10th ed., pp. 188-186). Boston, MA: South-Western Cengage Learning.

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